THE OCCURRENCE OF RAFTS FOR DISPERSAL OF LAND ANIMALS INTO THE WEST INDIES

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The origin of the fauna of the West Indies is either attributed to landbridge connections with the mainland (Barbour, 1914, 1916; Barbour and Noble, 1915; Scharff, 1922; Schuchert, 1935) or to waif dispersal over water by means of rafting or by windstorms (Darlington, 1938, 1957; Myers, 1938; Simpson, 1956; Williams and Koopman, 1952). Waif dispersal by wind and water, however, is the only means that can adequately explain the presence of certain faunal elements in the Antilles and the absence of others—conspicuous among the absentees are the carnivores and ungulates which certainly would have crossed any landbridge had one been available (Simpson, 1956). Some persons, merely because of the infrequency of suitable windstorms or raft materials, find it difficult to accept the possibility that an animal, or many animals, could be carried across an expanse of open sea and be deposited on an island to start a new population. It is my purpose to show that suitable rafts are sufficiently frequent in the Caribbean area to move considerable numbers of animals into the Antilles.

Perhaps one of the reasons that rafting is unacceptable as a means of dispersal is the conviction that substantial rafts (tree islands) are needed. These are indeed infrequent in occurrence. One such floating island with trees 30 feet high, sighted off the coast of North America in 1892, has been cited as evidence for rafting on at least four separate occasions (Powers, 1911; Matthew, 1939; Darlington, 1938, 1957). Other tree islands have been reported in the Molucca and Philippine islands (Lyell, 1834).

Far less substantial rafts have been reported to carry animals to sea. Clench (1925) reports a rattlesnake (*Crotalus adamanteus*) which was found on a raft of water hyacinth (*Eichhornia crassipes*) off the Florida coast. Guilding (1828; see also Purdy, 1839) reports a boa constrictor (*Constrictor constrictor*) which drifted ashore on St. Vincent Island in the Lesser Antilles.[1] It apparently was rafted

[1] Guilding (1828) states that this boa came ashore, killed a few sheep, and then was itself killed. With its skeleton in front of him, he remarked that there might be reason to fear his future ramblings through the forests of St. Vincent "had this formidable reptile been a pregnant female, and escaped to

250 miles (the approximate distance from the Orinoco River) on the trunk of a cedar tree. Feilden (1889) records "the interesting fact of an Alligator being transported alive on the trunk of a tree from the continent of South America to Barbados in 1886." The "Alligator" was probably *Crocodylus intermedius* from the Orinoco River. Barbour (1914) reports a specimen of *Crocodylus intermedius* which came ashore in Grenada in 1910, with no apparent raft. Prescott (1959) reports a jack rabbit (*Lepus californicus*) off the California coast on a raft of giant kelp (*Macrocystis pyrifera*) which measured only forty feet by twenty-five feet. It is evident from the above cases that floating tree islands for rafting animals across ocean barriers are unnecessary. Rafts, in the form of logs and floating herbaceous plants, undoubtedly exist in the Caribbean area in sufficient numbers to account for the origin of the present fauna.

In order to determine the frequency with which rafts enter the Caribbean, observations were made over a period of a month and a half during the summer of 1960 at the Rio Tortuguero, Limon Province, Costa Rica. Because of a longshore current flowing south, any rafts leaving the Rio Tortuguero would drift towards Colombia, but the principles set forth here can be applied to the coastal Caribbean in general because of the presence of similar physical and biotic factors. The Rio Tortuguero is a sluggish, low-gradient river which in times of low water becomes choked with floating vegetation. Frequently large mats of these plants break loose and drift out to sea. Schmidt (1944) described similar conditions in the Paraguay and Parana rivers of South America. He states that during periods of flood, animals seek refuge on the mats, and it is during these periods of high water that the mats are most apt to be swept away downstream. These mats are therefore potential rafts for animals. Logs are also present on the Tortuguero, but infrequent.

From 13 July to 29 August 1960 daily records were kept on the types and sizes of rafts which formed on the river. Additional

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a safe retreat." Purdy (1839) does not cite the source of his information about the boa, but he states that the snake "was found to contain many young ones, nearly ready to escape; and which, but for the destruction of the old one, would have taken up their abode in the woods." If this snake is the same one Guilding cites (which I believe to be the case) then Purdy's statement that the snake was pregnant is in error. However, these may be two different snakes that reached St. Vincent on separate occasions. Lyell (1834) and Wallace (1881) cite Guilding's article; Guppy (1917) cites Purdy.

records were kept on the wind, rain, and surf conditions requisite for getting these rafts out of the river and into the open ocean. The results of these observations are summarized in table 1.

TABLE 1.

Daily observations on raft formation in the Rio Tortuguero, Costa Rica, during the summer of 1960.

Date	Rain [1]	Wind [2]	Surf [3]	Square feet of Vegetation/minute [4]	Rafting [5]
13 July		W N		.5	
14	R	W E	H	.5	
15		W E	H	.5	
16		W	H	1—25	
17		E		25—50	
18	R	W	H	.5	
19		E E	H	.5	
20		E E	H	.5	
21		E E	H	.5	
22	R	E E	H	.5	
23		W E	H	.5	
24	R	W E	H	.5	
25		W E	H	.5	rafting
26	R	W E	H	100—500	
27		W E	H	100—500	
28			H	.5	
29	R	W E	H	.5	
30		W E	H	.5	rafting
31		W E	H	.5	
1 Aug.		W E	H	.5	
2		W E	H	.5	
3	R	W E	H	25—50	
4	R	W E	H	.5	
5	R	W E	H	.5	
6	R	W E	H	25—50	
7		W E	H	.5	
8	R	W E	H	.5	
9	R	W E	H	1—25	
10	R	W E	H	500—1000	
11	R	W E	H	100—500	rafting
12		W N	H	1—25	rafting
13		W W		500—1000	rafting
14		W E		.5	rafting
15		W E		.5	rafting
16		W E		.5	rafting

TABLE 1—Continued

Date	Rain [1]	Wind [2]	Surf [3]	Square feet of Vegetation/minute [4]	Rafting [5]
17		W E		.5	
18		W E	H	.5	
19		W E	H	.5	
20		E E	H	1—25	
21	R	W E	H	.5	
22		W E	H	1—25	
23		W W	H	1—25	
24		W W	H	.5	
25		W W	H	.5	
26	R	W W	H	.5	
27	R	W W	H	.5	
28	R	W W	H	1—25	
29 Aug.	R	W W	H	1—25	

[1] Days of rain are shown—the amount was not measured.

[2] Wind direction was recorded twice a day—first column at 07:00, second column at 19:00. West winds blow offshore.

[3] Heavy surf with whitecaps and breaking waves.

[4] Square feet of rafting vegetation passing a given point on the river each minute—size of individual rafts is not shown.

[5] Days when rafts successfully reached the open sea and drifted out of sight of land are shown. Observations were made at least three times a day—at 07:00, 13:00, and 19:00.

It will be noted from the table that each period of rafting is preceded by one or more days of rain. Any appreciable amount of rain will raise the level of the low gradient Rio Tortuguero several inches to a foot. This high water lifts the floating vegetation free of the bottom and allows the current to tear away large central portions. In such a way the rafts are formed. Low water between rainy spells permits the plants to grow out from the banks and form new mats of vegetation that will be torn away with the next high water. Every day of rain was not followed by a day of rafting (see table 1) because the vegetation mats were not always large enough to be torn loose by high water.

The rafts on the Rio Tortuguero are of five types: *Hydrocotyle* mats; water hyacinth mats (*Eichhornia*); water hyacinth-grass mats (*Eichhornia* and *Panicum);* logs; and trees. The *Hydrocotyle* rafts are small (less than 10 square feet) in size and extremely flimsy.

None traversed the surf to the open sea. The water hyacinth rafts are larger in size (up to 5,000 square feet) and considerably more sturdy. Many of these rafts floated out through the surf to the sea. The water hyacinth-grass rafts were the largest (up to 10,000 square feet) and sturdiest of the rafts. I attempted to tear several of these rafts apart by hand and had extreme difficulty in doing so. The hyacinth rafts are held together by their root system and intertwined leaves. In the water hyacinth-grass rafts, the tough stems of the grass grow in and around the intertwined hyacinths, and firmly lash the raft together. Log and tree rafts were not encountered during the study, although the local people state that numerous logs and trees drift down the river on occasion.

Once the rafts have reached the mouth of the river, they are at the mercy of the waves and eddies of current which usually tear them apart and cast them up on the beach. If, however, the surf is low (as it was on the last four days of rafting—see table 1), or there is an off-shore wind (west wind) to blow the rafts through the surf (as there was every morning when rafting occurred), then the rafts drifted out to sea and disappeared over the horizon. To a person standing on the beach (eye-level approximately 10 feet above sea level) and looking out to sea, the rafts (12-24 inches in height) disappear from sight about four nautical miles from shore (U.S. Coast and Geodetic Survey, 1958). Concerning the fate of the rafts beyond this point I can only guess. At least two local people (former seamen shipping between Colón, Panama, and San Andrés Island) report seeing such rafts fifty miles off shore.

Two or three days in sea water is sufficient to kill the water hyacinth (Penfound and Earle, 1948), but the water hyacinth-grass rafts would certainly hold together for a longer period of time. During the eight days of observed rafting an estimated 1,500,000 square feet of hyacinth and hyacinth-grass rafts (usually of more than 100 square feet each) entered the ocean from the Rio Tortuguero. The total observation period was 48 days. If the whole year is considered as similar to the seven weeks of observation, and if the total number of rivers entering the Caribbean from Central and South America is considered, the square feet of rafting material entering the Caribbean each year must be impressive.

That some of the rafts do reach the Antilles might be attested to by the presence of several species of water hyacinth in these islands, in addition to the common *Eichhornia crassipes* (see Small,

1933 (under the generic name *Piaropus*); Marie-Victorin and Leon, 1942).

These rafts could not transport large land vertebrates whose weight would tend to break the rafts apart. Certainly the available rafts could transport many small vertebrates and invertebrates into the Caribbean islands.

Barbour and Noble (1915:424) state that if rafting occurred "we could lie-to in the mid-Caribbean and watch the rafts go by. . . . " While this may not be possible, it is evident that studies on rafting can be conducted at any of the major low-gradient rivers along the Caribbean coast of Central and South America. During flood periods it would be possible to study raft formation, raft faunas, and, by following the larger rafts by boat or airplane, even discover how far they travel, and what the fates of their faunas are.

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